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Creators: Burd, Edward W.

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SHEET STEEL OPERATIONS

By EDWARD W. BURD, '30

The first sheet iron to be made in the United States was rolled in 1810 by means of small rolls driven by crude, inefficient, direct-connected, over-shot water wheels. Sheet steel had been made in Europe prior to this date, but there is little or no record of it until 1866 when Russian sheet steel came into prominence. Their rolls were even more inefficient than ours, and hammers were employed for the finishing processes.

Sheet steel practice involves the rolling out of a smooth flat sheet, true to gauge, free from excess seams, and with a constant thickness or gauge over the entire sheet. This last requirement has troubled strip mill designers more than any other phase of rolling work. It has oftentimes been remarked that better sheet iron was rolled years ago. While this may be partly true, the steel in itself is far superior to steel sheets of twenty years ago. Yet, as to the physical defects due to the rolling operation, men of years before may have been superior craftsmen to present-day rollers; for most of the rollers from 1900-1910 set up their own mills after each week's run, and hence were thoroughly acquainted with every detail of the set-up along the drive. Today, because of the pressure of increased production, men called millwrights look after and are solely responsible for the mills before the rollers' work begins.

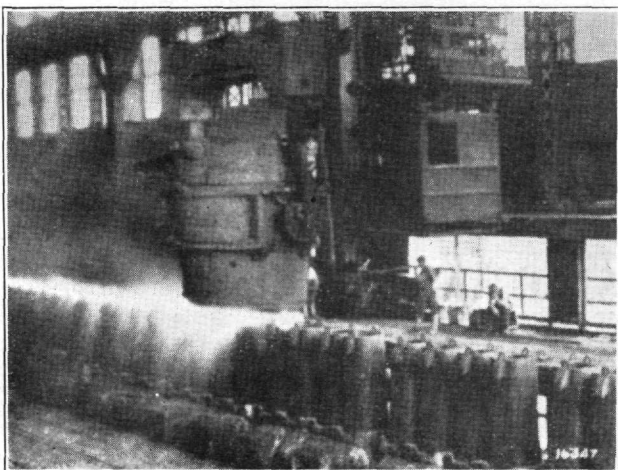
Nearly all sheet steel is made from basic open-hearth steel, the Bessemer process steel being superseded by the open-hearth process steel because of the uncertainty of control and the weakening effect of high phosphorus. The steel after being tapped from the open hearth is poured from a ladle into ingot molds, the poured ingots being carried along on flat gondolas. After external or side wall solidification has taken place the ingot molds are stripped from the ingots and the ingots removed to the soaking pits to prevent physical defects due to rapid cooling. The ingots are taken from the soaking pits, rolled into blooms and thence into sheet bars on the bar mills.

Sheet bars vary in width and thickness but are rolled to give a weight per linear foot of from 8 to 19 lb., the bars varying $\frac{1}{4}$ lb. per foot for each

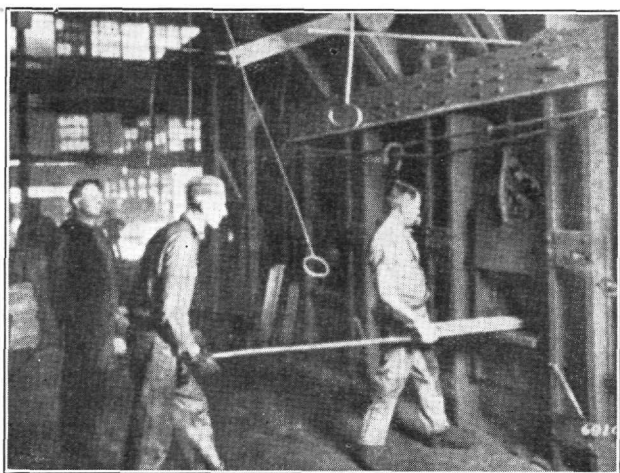
size. This variation gives a bar stock of forty-four sizes. If a jobbing mill is included in the plant, the bar weights will run from 8 to 48 lb. per linear foot and bar size classification becomes much more complicated. These bars are usually about thirty-six feet long and are cut into lengths which determine the width of the sheet to be rolled. If the specifications require a sheet 30 inches wide, 96 inches long, then fourteen $30\frac{3}{4}$ -inch lengths will be cut from this 36-foot bar. The short bars are then charged into pair furnaces and heated slightly above the critical range of low carbon steels. At the right temperature they are broken down on the roughing rolls. Here each bar is given two passes (the bars are worked in pairs) and then relayed to the finishing mills where the bars are given three more passes. Then they are matched up and given two passes. By this time the breakdown sheets are cold and further working will not produce any reduction in size. These half-way sheets are charged into the sheet furnaces in threes, heated to the right temperature, given two more passes on the finishing rolls, doubled matched, and charged back into the sheet furnace for another reheating. At the right temperature the doubled pack is removed from the furnace and passed through the finishing rolls. The number of passes may vary, due to the condition of the mill. If the mill is low it is sometimes necessary to give four passes on the finishes in order to get the length and gauge requirements.

The most important phase of mill operations is the constant attention to the maintenance of the rolls. Good superintendence plays a big part here, for operating methods must be continually varied to avoid the many troubles possible in a line of mills. Careful superintendence on the warming-up turn eliminates much roll breakage, because it is thought by most engineers that temperature stress due to faulty heating up of the rolls weakens the internal structure of the graphitic core. The roughing rolls are usually made of cast iron, with a hard chilled surface and a soft graphitic core to absorb shock. Roughing rolls are sometimes made of steel, however. They are turned straight and cooled by means of fine streams of water playing over them. This cooling process keeps the rolls around the 300 deg. Fahr. and assures uniform expansion.

Finishing rolls are always made with a hard cementitic surface by chill-casting and a soft graphitic core to act as a shock absorber. Some mill operators have both rolls turned with a concavity; others with a straight top roll and a concave bottom roll. Due to the continual passage of hot iron through the rolls and this iron's being localized over the center of the roll, the center expands more than the ends and a concavity is necessary to maintain a straight or slightly dished but flush surface when hot. This curvature between rolls, which is almost imperceptible, gives a better gripping power than if both rolls were flat, as well as excellent control of the pack after entering the rolls, for there is a slight vertical pull on



Molten steel teeming from a ladle into ingot molds.



Short bars being charged into pair furnaces by pair heater. From these bars are rolled sheets of varying thickness and length.

each side of the mill. If the top and bottom rolls become perfectly flat after warming up, there is much spreading of the iron from one side of the roll to the other. Also, if one side of the rolls gets too hot, a flatness between rolls develops and the pack tends to run to this side of the mill. As a result the sheet pack is circled, and only by careful shearing is the required sheet obtained. Steam is played on the rolls during spells between heats to maintain the roll temperature. Water through rubber tubing is played over the necks to keep their temperature down and prevent hot necks.

Little change has taken place in sheet steel practice over a period of thirty years. There is much reason to believe that sheet steel produced fifteen years ago was superior to the product of today (so far as the rolling operation is concerned). But now indications are that a big change in sheet steel manufacture is taking place. The strip process, if successfully operated, will reduce one of the most interesting steel fabrication spectacles to a mere matter of machine, heat, and power, the human element playing only a small part. Today the roller and his crew seem astonishingly clever with a pair of tongs. Their stamina against fatigue in intense heat is amazing. The charging, drawing, matching, and doubling, actual rolling, and action of the catchers as they swing hot bars from the roughing to finishing mills are very interesting spectacles.

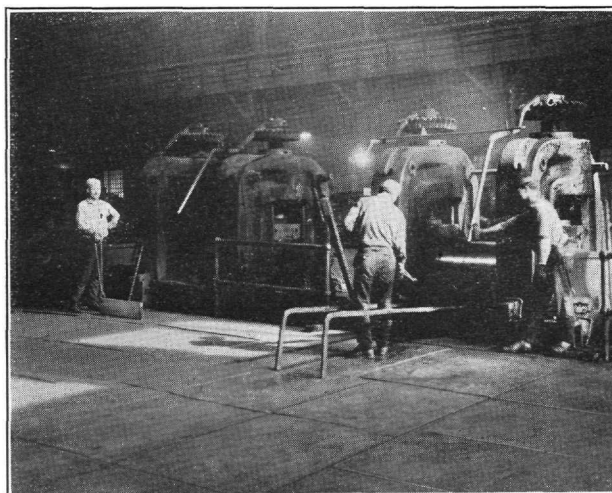
After the rolling process the packs are sheared, opened, and piled, ready to be weighed and sent to the cold roller. From here the lifts of sheet steel are removed to the annealing floor, charged into annealing furnaces and fired for twenty hours. The sheets are then cooled with the furnace for ten or twelve hours. The annealing process softens the sheets and puts them in condition for further cold working or for certain physical requirements; it relieves internal stresses which develop as the heat of the sheet falls below the critical range; it produces maximum grain refinement with the greatest ductility and tensile strength possible. Heavy gauge sheet steel is annealed by the open box process; that is, the sheets are passed slowly through a furnace in which the temperature decreases as the sheets pass to the discharge end. The flame plays directly over the sheets and coats them with a dense blue oxide. Because of this coating, open annealing

is often called "blue" annealing. With the lighter gauges, however, in order to get blue annealed stock, live steam is driven into the closed annealing box immediately after the box is drawn from the furnace. In order to get thorough "oxidizing" by steam the sheets must be rippled on a press; that is, temporarily grooved so that the complete surface of every sheet can be acted upon by the steam. By this means the intense blue oxide sheet is obtained. This stock is used primarily in stove fabrication. With the lighter gauges it is necessary to seal the box with large cast-steel lids and sand up the junction between lid and bottom. Any access of air causes extreme scaling of the steel at the annealing temperature and burnt steel due to improper annealing must be scraped.

When the sheets must withstand weathering they are galvanized (coated with a zinc alloy). This coating retards rusting and presents a more pleasing appearance than crude black sheets. The coating may be applied before or after the forming of the finished article. It is best, however, to add the coat to the finished product, since the forming process may crack the zinc coating and a thicker covering is usually obtained. The first step in galvanizing is cleaning or pickling the sheets in a dilute solution of sulphuric acid. To give thorough contact between the acid and sheets, they are worked up and down in the vat until all surface defects are removed. This process shortens the cleaning period to about one-half the time formerly necessary. Shortening the process not only saves acid but also decreases the sheet loss, for a longer pickling operation may actually harm the sheets. At the galvanizing machine the sheets pass through a set of rolls immersed in a bath of molten spelter or alloyed zinc, kept at about 825 deg. Fahr. As the sheets emerge from the machine, they pass through a set of rolls which squeezes off excess spelter, leaving a thin, tight galvanizing coat. Three factors govern the thickness of the coating: first, the temperature at which the molten bath of spelter is maintained; second, the speed with which the sheets are run through the machine; and third, the elevation of the metal above or below the line of contact of the exit rolls.

Normal atmospheric conditions form a coating

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Rougher at rolls giving break downs last pass after matching.

SHEET STEEL

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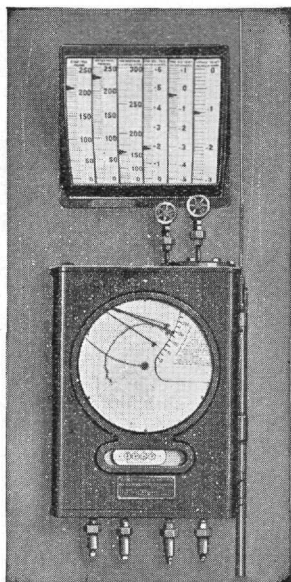
of zinc carbonate, which is insoluble in water and a good protector of the zinc and steel underneath. When the atmosphere is contaminated with sulphur dioxide, however, the acid formed in the presence of moisture injures the galvanized surface. The steel is then attacked by the elements.

It is possible to coat the black sheets with a lead-tin alloy of 10 per cent tin and 90 per cent lead. This coating is applied very thin, the sheets presenting a smooth surface without any spangling as in the case of a galvanized surface. Sheets treated in this way are called long terne sheets and because of the smooth surface are used where a fine painted surface is desired.

Much sheet steel is enameled, the enameling industry in itself representing extensive investments in capital and labor. Steel sheets for enameling purposes are rolled from special open-hearth heats to insure a uniform steel. Vanadium is added to deoxidize the bath and remove dissolved oxygen and other gases.

The labor cost of changing a bar of steel into a sheet of steel is about twelve dollars per gross ton, however, the cost varies according to the gauge of the sheets rolled. Some conception of the annual payroll can be gained from considering that 12,000,000 tons of sheet steel were produced in 1927. The industry of steel production presents a wide and ever-changing field of steel utilization as time goes on and just what the future will bring in the line of increased utilization is highly problematical but it is inevitable that the field will be widely varied.

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